

**TAXONOMIC AND ULTASTRUCTURAL STUDY OF  
*TRACHELOMONAS* EHR. AND *STROMBOMONAS* DEFL.  
(EUGLENOPHYTA) FROM OXBOW LAKES IN ALABAMA  
AND INDIANA (U.S.A.)**

Visitación CONFORTI<sup>1</sup> and Gea-Jae JOO<sup>2</sup>

1. Dept Biología, Fac. Cs. Exactas y Naturales, Ciudad Universitaria, Pab. II,  
1428, Buenos Aires, Argentina.
2. Dept. of Biology, Pusan National University, South Korea.

**ABSTRACT** - This paper describes and comments on 79 species and infraspecific taxa of *Trachelomonas* Ehr. and *Strombomonas* Defl. (Euglenophyta) from oxbow lakes in Alabama and Indiana, U.S.A. On the basis of the organisms studied we propose 9 new species, 7 new varieties and 1 new forma. Thirteen taxa have been examined by scanning electron microscopy.

**RÉSUMÉ** - 79 taxons appartenant aux genres *Trachelomonas* Ehr. et *Strombomonas* Defl. (Euglenophyta) provenant de bras morts de rivières d'Alabama et d'Indiana, U.S.A., sont étudiés. Nous proposons 9 nouvelles espèces, 7 nouvelles variétés et 1 nouvelle forme. Treize taxons ont été examinés au microscope électronique à balayage.

**KEY-WORDS** - Taxonomy, morphology, ultrastructure, *Trachelomonas*, *Strombomonas*, Euglenophyta.

## INTRODUCTION

Oxbow lakes (formed by river meanders) are common and often highly productive floodplain features of major rivers around the world (Joo & Ward, 1990 a, b). The limnology of these lakes is very poorly known. Due to annual flooding, many water bodies within the floodplain undergo substantial limnological changes. Depending on the successional stage, oxbow lakes exhibit a wide range of land-water interface zones.

In a previous study (Joo, 1990), high diversity and abundance of euglenoids were found in oxbow lakes in Alabama. In water samples from these lakes, we have observed many taxa belonging to the genera *Trachelomonas* Ehr. and *Strombomonas* Defl., euglenoids with distinctive envelope structures. In these genera, the morphology of the envelope is a key taxonomic criterion to be used for identification. This fact is shown in the principal books and publications on cytology and taxonomy of euglenoids in general (e.g. Huber-Pestalozzi, 1955; Leedale, 1967; Popova, 1966; Starmach, 1983; Tell & Conforti, 1986), as well as those focused on genus *Strombomonas* (e.g. Deflandre, 1930; Hager, 1979; Tell & Conforti, 1984 and 1988), or the treatises on

*Trachelomonas* (e.g. Balech 1944; Conforti & Tell, 1986; Couté & Thérézien, 1985; Deflandre, 1926; Dodge, 1975; Leedale, 1975; Rino & Pereira, 1990).

Despite the high abundance of euglenoids in shallow water bodies in general, no major taxonomic or ecological investigations have been carried out in North America. In this paper we describe several new records of *Trachelomonas* Ehr. and *Strombomonas* Defl. taxa, some of which are established as new species, new varieties and a new forma. In addition, the ultrastructure of 13 taxa is included in this study.

## MATERIALS AND METHODS

Three oxbow lakes representative of different developmental stages in the Black Warrior River basin (Alabama), and one oxbow lake (Indiana) were selected for this study. Alabama oxbow lakes (Cypress Cutoff Lake: CCL, Touseon Lake: TL, Little Keaton Lake: LKL) are deep (4-7 m maximum depth during low water level), and their ages range from 70 to over 500 years. For a detailed description of the habitat, see Joo & Ward (1990. a). Tristate Oxbow Lake (TOL) was formed by the Great Miami River which has its source in mid-Ohio. TOL is located in the floodplain before the parent river joined into the Ohio River (longitude 84°50', latitude 39°07'). This lake is less than 150 years old and very shallow (70 cm deep during low water level). For the purpose of this paper, we analyzed 17 water samples which were identified by code numbers (see table 1). These samples have been chosen for their high abundance of Euglenophyta from the monthly samples collected from 1988 to 1990 (Alabama samples) from 1991 to 1992 (Indiana samples). The water samples were collected at

Station	Code number	Date
TOL	1	3/31/91
	2	5/4/91
	3	5/9/91
	4	5/14/91
	5	6/1/91
	6	6/13/91
	7	7/15/91
LKL	1	11/1/90
	2	12/3/90
	3	12/6/90
	4	1/6/91
CCL	1	6/1/90
	2	12/16/90
	3	1/6/91
TL	1	11/1/90
	2	12/4/90
	3	3-6/1/91

Table 1 - 17 water samples identified by code numbers. TOL: Tristate Oxbow Lake; LKL: Little Keaton Lake; CCL: Cypress Cutoff Lake; TL: Touseon Lake.

1 m depth using a Van Dorn sampler and preserved with Lugol's solution. For taxonomic identifications a Leitz binocular microscope was used. For the SEM work, unpreserved organisms were filtered onto a 0.45  $\mu\text{m}$  cellulose acetate filter (Millipore) and air dried for 3-4 hours. These samples were then sputter coated with gold-palladium (Hummer VI Sputtering System). Specimens were examined and photographed using a Hitachi S-2500 (Univ. of Alabama) and a Phillips 505 scanning microscopes (Miami University).

We have recorded 79 taxa (table II); only the organisms that are new to science and those which the ultrastructure was observed, are described in the text. In certain cases, additional comments on relevant morphological or distributional characteristics are furnished.

The samples were deposited in the collection of the Limnology Laboratory of the Department of Biological Sciences, University of Buenos Aires.

## RESULTS

### Taxonomical descriptions

#### Fam. Euglenaceae

##### *Trachelomonas* Ehr.

##### *T. abrupta* Swir emend. Defl. var. *minor* Defl. Figs. 20, 89-91

Lorica 20-22  $\mu\text{m}$  long, 9.5-11  $\mu\text{m}$  broad, cylindrical with the sides slightly curved to parallel. Ends rounded, the posterior somewhat acuminate. Pore provided with an annular thickening, surrounded by a crown of 7-9 conical spines of even length or longer than the rest of the envelope. Membrane with punctuations (0.11-0.14  $\mu\text{m}$  diam.), fairly separated from each other (200-230/100  $\mu\text{m}^2$ ), conical spines (0.5-1 x 0.18-0.25  $\mu\text{m}$ ) scattered (180-200/100  $\mu\text{m}^2$ ) and very small warts (0.03-0.04  $\mu\text{m}$  diam.), closely distributed (3500-4000/100  $\mu\text{m}^2$ ). Europe, Africa, Argentina, Recorded in the U.S.A. for the first time.

Rino & Pereira (1989-90) discussed the envelope ornamentation of this variety. We agree in all with their observations.

##### *T. bacillifera* Playf. var. *minima* Playf. Figs. 25, 87

Lorica 22-26  $\mu\text{m}$  long, 19-21  $\mu\text{m}$  broad, ovoid to broadly ellipsoid, punctuated (310-340/100  $\mu\text{m}^2$ ) and covered with rod-like obtuse spines (0.5-1  $\mu\text{m}$  long, 0.5-0.75  $\mu\text{m}$  diam.) closely distributed (440-450/100  $\mu\text{m}^2$ ). Pore, 3-3.5  $\mu\text{m}$  diam., surrounded by an annular thickening. Membrane reddish-brown. Widespread.

##### *T. cordata* (Drez.) Defl. fo. *minor* Defl. Figs 81-82

Lorica 10-12  $\mu\text{m}$  long, 8-10  $\mu\text{m}$  broad, heart-shaped. Pore surrounded by a subcylindrical collar (1.5-2 x 2.5-3  $\mu\text{m}$ ). Membrane smooth.

This forma was originally described by Deflandre (1926) in materials from Venezuela, ours is the only other known record.

Table II: *Trachelomonas* and *Strombomonas* taxa from the studied oxbow lakes of U.S.A.

	Sample code	Illustration
<i>Trachelomonas</i>		
<i>T. abrupta</i> Swir. emend. Defl. var. <i>minor</i> Defl.	TOL 4, 5, 6	20, 89-91
<i>T. bacillifera</i> Playf. var. <i>minima</i> Playf.	TOL 4; LKL 2, 3; CCL 2	25, 87
fo. <i>sparsispina</i> Defl.	LKL 1, 2; CCL 2	15
<i>T. cordata</i> (Drez.) Defl.	TOL 4, 5, 7	30
fo. <i>minor</i> Defl.	TOL 3, 5	81-82
var. <i>punctata</i> var. nov.	TOL 4	31
<i>T. crebea</i> Kell. emend. Defl.	TOL 4, 5	29
<i>T. curta</i> Da Cunha emend. Defl. var. <i>minima</i> Tell & Zaloc	TOL 2, 4, 5, 6, 7	3
<i>T. dybowskii</i> Drez.	TOL 2	10
<i>T. granulata</i> Swir. emend. Defl.	TOL 5	32
<i>T. granulosa</i> Playf.	CCL 2	24
<i>T. hispida</i> (Perty) Stein emend. Defl.	LKL 3	19
fo. <i>minor</i> Bourr.	TOL 4, CCL 2	18
<i>T. intermedia</i> Dang.	TOL 7, CCL 2, 3	9, 83
<i>T. lacustris</i> Drez. var. <i>ovalis</i> Drez. em. Defl.	TOL 5, 6	88
<i>T. mangini</i> Defl.	TOL 4	27
<i>T. minima</i> Drez.	TOL 4, CCL 2	15
<i>T. nexilis</i> Palmer	TOL 2, 4, 5, 6, 7; LKL 4; CCL 2	12
<i>T. oblonga</i> Lemm.	TOL 4, 5, 7	6
var. <i>attenuata</i> Playf.	TOL 7	7
var. <i>truncata</i> Lemm.	TOL 6	8
<i>T. pusilla</i> Playf.	TOL 1, 2, 4, 5, 6, 7; CCL 2	4
var. <i>punctata</i> Playf.	TOL 2, 4, 5, 6, 7; CCL 2	5
<i>T. raciborskii</i> Wol.	TL 3	85
var. <i>nova</i> Drez.	LKL 1	84
<i>T. robusta</i> Swir. emend. Defl.	TOL 4; LKL 4; CCL 2; TL 3	22, 86
<i>T. rugulosa</i> Stein emend. Defl.	TOL 4, 6; CCL 1, 2	13
fo. <i>parallela</i> Tell & Zaloc.	TOL 2, 5; CCL 1, 2	14
<i>T. selecta</i> Defl.	TOL 7	16
<i>T. silvatica</i> Swir.	TOL 7	26
<i>T. similis</i> Stokes var. <i>spinosa</i> Hub.-Pest.	TOL 4	23
<i>T. verrucosa</i> Stokes fo. <i>irregularis</i> Defl.	LKL 1, 2; CCL 2	21, 79-80
<i>T. vulvocina</i> Ehr.	TOL 1, 2, 4, 5, 6, 7; LKL 2, 3, 4; CCL 1; TL 3	1, 77-79
var. <i>punctata</i> Playf.	TOL 5	2
<i>T. waycikii</i> Koczw. fo. <i>pusilla</i> (Drez.) Popova	TOL 7	17
<i>T. zorenensis</i> Lef.	TOL 2	11

*Strombomonas*

<i>S. acuminata</i> (Schm.) Defl.	TOL 2, 4, 6, 7	36 a-c
var. <i>amphora</i> Playf.	TOL 5	38 a-c
<i>S. aspera</i> (Skv.) Defl.	TOL 6	52 a, b
<i>S. asymmetrica</i> (Roll) Popova	TOL 2, 6, 7	50
<i>S. borysthemiensis</i> (Roll) Popova	TOL 4, 5, 7	40
<i>S. brebicaudata</i> sp. nov.	TOL 4, 5	67 a, b
<i>S. conica</i> sp. nov.	TOL 4, 6, 7	61 a-c
<i>S. cylindrica</i> sp. nov.	TOL 5, 6	63 a-g, 92
var. <i>minor</i> var. nov.	TOL 2, 4, 6	60 a, b; 93, 94
<i>S. elegans</i> sp. nov.	TOL 4, 5, 7	74 a-d
<i>S. elongata</i> sp. nov.	TOL 2, 5	72 a, b
var. <i>minor</i> var. nov.	TOL 6	68 a, b
<i>S. eurystoma</i> (Stein) Popova	TOL 7	33
fo. <i>incurva</i> (Buz.) Popova	TOL 5, 7	35 a, b
fo. <i>sinensis</i> (Skv.) Popova	TOL 6	34
<i>S. fluviatilis</i> (Lemm.) Defl.	TOL 2, 5, 6, 7	48 a, b
<i>S. gibberosa</i> (Playf.) Defl.	TOL 5	41
<i>S. globulosa</i> sp. nov.	TOL 4, 7	66 a, b
<i>S. lanceolata</i> (Playf.) Defl.	TOL 2, 5, 7	49 a-c
var. <i>minor</i> var. nov.	TOL 5, 6	70 a, b
<i>S. massartii</i> Hub.-Pest.	TOL 5, 7	37
<i>S. minuta</i> sp. nov.	TOL 6, 7	73 a-m
<i>S. napiformis</i> (Playf.) Defl. var. <i>brevicollis</i> Playf. fo. <i>minor</i> fo. nov.	TOL 6	43 a, b
<i>S. oblonga</i> sp. nov.	TOL 2, 4, 6	62
<i>S. pascherana</i> (Skv.) Defl.	CCL 2	59
<i>S. praeliaria</i> (Palmer) Defl.	TOL 5	42
<i>S. recurvata</i> sp. nov.	TOL 2, 4, 5, 6, 7	76 a-g
<i>S. rotundata</i> (Playf.) Defl.	TOL 2, 4	47 a, b
<i>S. scabra</i> (Playf.) Tell & Conf.	TOL 1, 2, 4, 5, 6, 7; CCL 2	54
var. <i>coberensis</i> (Defl.) Tell & Conf.	TOL 2, 4	56 a, b
var. <i>cordata</i> (Playf.) Tell & Conf.	TOL 2, 4	55
var. <i>cordata</i> fo. (Defl.) comb. nov.	TOL 2	65
var. <i>coronata</i> var. nov.	TOL 2, 4; CCL 3	58 a-d, 95
var. <i>longicollis</i> (Playf.) Tell & Conf.	TOL 2, 4, 5	57
var. <i>ovata</i> f. <i>minor</i> (Defl.) Tell & Conf.	TOL 2, 4, 5, 6, 7	64 a-c
<i>S. schauinslandii</i> (Lemm.) Defl.	TOL 2, 4, 5, 6	53 a-c
var. <i>minor</i> var. nov.	TOL 7	69 a, b
<i>S. treubii</i> (Wol.) Defl. var. <i>javanica</i> Wol.	CCL 2	45
<i>S. urceolata</i> (Stokes) Defl.	TOL 5, 6	44 a, b
var. <i>minor</i> var. nov.	TOL 2, 4, 5	71 a-g
<i>S. vaseformis</i> Philip.	TOL 5	75 a, b
<i>S. vermontii</i> (Defl.) Defl. fo. <i>commune</i>	TOL 2, 4, 5, 6	51 a, b
<i>S. verrucosa</i> (Dađay) Defl. var. <i>genuina</i> Defl.	TOL 2, 6	46
var. <i>zmiewika</i> (Swir.) Defl.	TOL 2, 5, 7	39 a, b

var. *punctata* var. nov.

Fig. 31

*A specie lorica punctata differt, 16.5-18 µm long., 13-15 µm lat. In Tristate Oxbow lacu, Indiana, U.S.A., 5/14/91. Iconotypus: figura nostra 31.*

Lorica 16.5-18 µm long, 13-15 µm broad. This variety differs from var. *cordata* ■ the membrane being provided with small dense punctuations.

*T. curta* Da Cunha emend. Defl. var. *minima* Tell & Zaloc.

Fig. 3

Lorica 8-9 µm long; 9-10 µm broad. This variety was originally reported by Tell & Zalocar (1985) in materials from Chaco, Argentina. Notoriously, these fresh-water bodies are very similar to TOL. This is the only other known record of this taxon in the world.

*T. granulata* Swir. emend. Defl.

Fig. 32

The organisms recorded from Tristate Oxbow lake were smaller than those described by Deflandre (1926); 18-20 µm long, 14-15 µm broad. Widespread.

*T. hispida* (Perty) Stein emend. Defl. fo. *minor* Bourr.

Fig. 18

Lorica 11-14 µm long, 10.5-13 µm broad. The lorica that occurred in our samples are smaller than those described by the author of the forma (18-20 x 15-16 µm). Europe, Guadeloupe Island, India. First record for the U.S.A.

*T. intermedia* Dang.

Figs. 9, 83

Lorica 13-16 µm long, 12-14 µm diam., broadly ellipsoid; pore (2.6-3 µm diam.) surrounded by a ring-like thickening. Membrane yellowish to deep brown, fine and sparsely punctuated (110-130/100 µm<sup>2</sup>). Widespread.

*T. lacustris* Drez. var. *ovalis* Drez. emend. Defl.

Fig. 88

Lorica 20-25 µm long, 14-16 µm diam., broadly ellipsoid; pore (2.5-3 µm diam.) surrounded by a ring-like thickening. Membrane yellowish to reddish-brown, closely punctuated (380-420/100 µm<sup>2</sup>) and ornamented with conical spines (0.5-1 µm long, 0.3-0.5 µm diam.) very scattered distributed (52-60/100 µm<sup>2</sup>). Argentina, France, Poland. First record for the U.S.A.

The organisms observed showed the spines less closely distributed (250-300/100 µm<sup>2</sup>), than those described by Conforti & Tell (1986).

*T. mangini* Defl.

Fig. 27

The lorica of this species are thinner than those described by Deflandre (1926); 20-21 µm long, 11-12 µm broad. Argentina, Europe. First record for the U.S.A.

*T. minima* Drez.

Fig. 15

Lorica 10.5-12 µm long; 11-12 µm broad. This species was found in materials from Asia and Europe, this is the first record in materials from Asia and Europe, this is the first record for America.

*T. raciborskii* Wol.

Fig. 85

Lorica 27-32 µm long, 22-25 µm broad, ellipsoid. Pore without collar (2.5-3 µm diam.), surrounded by a ring-like thickening. Membrane yellowish or reddish-brown.

strongly punctuated ( $125-150/100 \mu\text{m}^2$ ) ornamented with conical spines ( $1.5-2 \times 0.5-0.7 \mu\text{m}$ ) distributed mainly around the ends, some also scattered on the middle surface. Widespread.

*var. nova* Drcz.

Fig. 84

Lorica  $25-28 \mu\text{m}$  long,  $22-24 \mu\text{m}$  broad, elongated-ellipsoid, sides arched and poles broadly rounded, punctuated ( $80-100/100 \mu\text{m}^2$ ) with somewhat irregular short spines ( $0.6-0.8 \mu\text{m}$  distributed only the anterior end. Pore without collar. Membrane deep or reddish brown. Argentina, Poland. First record for the U.S.A.

*T. robusta* Swir. emend. Defl.

Figs. 22, 86

Lorica  $22.5-26 \mu\text{m}$  long,  $18.5-24 \mu\text{m}$  broad, ellipsoid strong and irregularly punctuated ( $80-100/100 \mu\text{m}^2$ ), with robust conical sparsely placed spines ( $2-3 \times 0.75-1 \mu\text{m}$ ). Pore without collar, normally surrounded by some spines whose length is equal to or greater than that of the ones on the body of the envelope, divergent or not. Membrane deep or reddish-brown. Widespread.

The organisms observed were less closely punctuated ( $450-500/100 \mu\text{m}^2$ ), than those described by Conforti & Tell (1986).

*T. rugulosa* Stein emend. Defl. *fo. parallela* Tell & Zaloc.

Fig. 13

Lorica  $18-19 \mu\text{m}$  long;  $17-18 \mu\text{m}$  broad. This forma was originally described by Tell & Zalocar (1985) in samples from Chaco, Argentina, where environmental conditions are very similar to those of our fresh-water bodies. Argentina, Brazil, U.S.A.

*T. selecta* Defl.

Fig. 16

The specimens recorded from Tristate Oxbow Lake were smaller than those described by Deflandre (1926),  $12-14 \mu\text{m}$  long,  $9.5-11 \mu\text{m}$  broad. Argentina, Poland. First record for the U.S.A.

*T. silvatica* Swir.

Fig. 26

Lorica  $24-27 \mu\text{m}$  long,  $16.5-18 \mu\text{m}$  broad. Asia. Europe. Recorded for the first time in America.

*T. verrucosa* Stokes *fo. irregularis* Defl.

Figs. 21, 79-80

Lorica  $10-11 \mu\text{m}$  long,  $11-12 \mu\text{m}$  broad, spherical to subspherical. Pore ( $1.5-1.8 \mu\text{m}$  diam.) surrounded by a annular thickening. Membrane yellowish to deep brown, ornamented with very small closely distributed granulations or warts ( $500-520/100 \mu\text{m}^2$ ). France, Poland, Portugal. Recorded for the first time in America.

In the specimens described by Rino & Pereira (1989-90) the warts were less closely distributed ( $200-350/100 \mu\text{m}^2$ ) than in ours: we suppose that this character could change with loricae age.

*T. volvocina* Ehr.

Figs. 1, 77-79

Lorica  $8-18 \mu\text{m}$  diam., spherical; pore  $1.6-2 \mu\text{m}$  diam., with or without ring thickening ( $1.8-2 \mu\text{m}$  thickness). Membrane smooth, sometimes slightly undulate (fig. 78), hyaline yellowish, clear to deep reddish-brown. Widespread.

*Strombomonas* Defl.*S. aspera* (Skv.) Defl.

Figs 52 a, b

Lorica 26.5-30  $\mu\text{m}$  long, 13-14  $\mu\text{m}$  broad, elongated-ellipsoid with the hind end sometimes attenuated, pore surrounded by a broad conical collar (4-7 x 3-4  $\mu\text{m}$ ) which appears as a continuation of the sides of the lorica, distal end straight or oblique. Membrane hyaline to yellowish, irregularly thickened along the contour. This species was originally found in China, ours is the only other record in the world.

Deflandre (1926) considered this species insufficiently described; and later (1930), he noticed that this taxon was doubtful. We coincide with Deflandre's opinion on the original description, even though our specimens are very similar to the Skvortzov's iconotypes (1922).

*S. brevicaudata* sp. nov.

Figs 67 a, b

Lorica 21-23  $\mu\text{m}$  long., 10.5-14  $\mu\text{m}$  lat., ovata, symmetrica. Collum cylindricum. Polus posterior, cauda brevis, acuta attenuatus. Paries hyalinus, marginibus crassis irregularibus. In Tristate Oxbow lacu, Indiana, U.S.A. 5/14/91, 6/1/91. Iconotypus: figura nostra 67 a.

Lorica 21-23  $\mu\text{m}$  long., 10.5-14  $\mu\text{m}$  broad, ovate, symmetrical. Pore surrounded by a cylindrical collar. Hind end gradually tapered to a short and pointed caudus (1.3-2  $\mu\text{m}$ ). Membrane hyaline with slight irregular margins.

*S. conica* sp. nov.

Figs 61 a-c

Lorica 16-21  $\mu\text{m}$  long., 9.5-11  $\mu\text{m}$  lat., forma conici, symmetrica. Polus anterior depressus, porus sine collum. Polus posterior rotundatus acuminatus. Paries hyalinus, marginibus crassis irregularibus in ambitu. In Tristate Oxbow lacu, Indiana, U.S.A. 5/14/91, 6/13/91, 7/15/91. Iconotypus: figura nostra 61 a.

Lorica 16-21  $\mu\text{m}$  long, 9.5-11  $\mu\text{m}$  broad, cone-shaped, symmetrical. Anterior end plain, pore without collar (2-2.5  $\mu\text{m}$  diam.). Hind end rounded to acuminate. Membrane hyaline, irregularly thickened along the contour.

*S. cylindrica* sp. nov.

Figs 63 a-g, 92

Lorica 23-28  $\mu\text{m}$  long., 13-16  $\mu\text{m}$  lat., cylindrica, lateribus irregulariter undulatis, polus late rotundatus or planus, ovata conspectu apicale. Porus nullis collum, circumdatus anulis crassis. Paries crassus, punctatus, abundantes particulae exogennae adhaerea super superficiem, subpalidae, discoideae, sine pyrenoidibus. Paramylon forma baculi. In Tristate Oxbow lacu, Indiana, U.S.A. 6/1/91., 6/13/91. Iconotypus: figura nostra 63 a-b.

Lorica 23-28  $\mu\text{m}$  long, 13-16  $\mu\text{m}$  broad, cylindrical with the sides irregularly undulated, ends broadly rounded or flattened, ellipsoid in apical view. Pore without collar, surrounded by an annular thickening. Membrane thick, coarse, punctuated and with numerous adhering particles on its surface; yellowish to light brown. Chromatophores numerous, discoid and without pyrenoid. Paramylon rod-shaped.



var. *minor* var. nov.

Figs 60 a, b; 93, 94

*A specie minoribus dimensionibus differt. Lorica 14-20 µm long., 11-13 µm lat. In Tristate Oxbow lacu, Indiana, U.S.A. 5/14/91, 5/14/91, 6/13/91. Iconotypus: figura nostra 60 b.*

This variety presented the same characteristics as the type, the only difference being the smaller dimensions of the envelope, 14-20 µm long, 11-14 µm broad. Pore without collar, sometimes adhering particles (figs. 93, 94) arranged like a crown surrounding the pore.

*S. elegans* sp. nov.

Figs 74 a-d

*Lorica 31-34 µm long., 10-12 µm lat., ellipsoidalis extendita a cylindrica, lata aliquid plana. Collum amplius, deficiens, dilatatus in extremo distale. Polus posterior in cauda conici, obliqua attenuatus. In Tristate Oxbow lacu, Indiana, U.S.A., 5/14/91, 6/1/91, 7/15/91. Iconotypus: figura nostra 74 c.*

Lorica 31-34 µm long, 10-12 µm broad, ellipsoid-elongate to cylindrical, sides sometimes flattened, continuing abruptly towards the anterior end to form a broad neck (3-6 x 4-6 µm) which is widened and irregular at the tip. Hind end tapered to an oblique, conical caudus (2.5-6 µm long).

*S. elongata* sp. nov.

Figs. 72 a, b

*Lorica 29-30 µm long., 8-10 µm lat., cylindrica circi breviter irregularis. Collum amplius, obliquus extremo distale. Polus posterior, cauda recta or curva. Paries hyalinus, tenuis, rugosus. In Tristate Oxbow lacu, Indiana, U.S.A., 5/14/91, 6/1/91. Iconotypus: figura nostra 72 a.*

Lorica 29-30 µm long., 8-10 µm lat., cylindrical, lateral margins slightly irregular. Pore surrounded by a wide collar (4-4.5 µm diam.), oblique at the distal end. At the rear ending in a right or curved caudus, 4-5 µm long. Membrane hyaline, thin and rough.

var. *minor* var. nov.

Figs 68 a, b

*A specie minoribus dimensionibus differt. Lorica 21-23 µm long., 7-8 µm lat. In Tristate Oxbow lacu, Indiana, U.S.A., 6/13/91. Iconotypus: figura nostra 68 b.*

Lorica 21-23 µm long, 7-8 µm broad. *S. elongata* var. *minor* differs from the type variety in the smaller dimensions of the envelopes.

*S. eurystoma* (Stein) Popova fo. *sinensis* (Skv.) Popova

Fig. 34

Lorica 27-30 µm long, 17.5-20 µm broad. This form was originally found in China, it is the only other known record in the world.

*S. globulosa* sp. nov.

Figs. 66 a, b

*Lorica 17-19 µm long., 10-13 µm lat., ellipsoidalis. Collum breve, leviter exampatus ad extremum distalem. Polus posterior, constrictus abruptum in cauda breve acuta. Paries hyalinus, tenuis, circi irregularis. In Tristate Oxbow lacu, Indiana, U.S.A., 5/14/91, 7/15/91. Iconotypus: figura nostra 66 b.*

Lorica 17-19  $\mu\text{m}$  long, 10-13  $\mu\text{m}$  broad, ellipsoid with a short collar slightly widened towards the tip end; hind end abruptly narrowed to a short pointed caudus. Membrane hyaline, thin, with irregular lateral margins.

var. *minor* var. nov.

Figs. 70 a, b

*A specie minoribus dimensionibus differt, 17-19  $\mu\text{m}$  long., 7.5-8.5  $\mu\text{m}$  lat. In Tristate Oxbow lacu, Indiana, U.S.A., 5/14/91, 6/13/91. Iconotypus: figura nostra 70 b.*

Lorica 17-19  $\mu\text{m}$  long, 7.5-8.5  $\mu\text{m}$  broad. *S. lanceolata* var. *minor* differs from the type variety in the considerably smaller dimensions of the envelopes.

*S. minuta* sp. nov.

Figs. 73 a-m

*Lorica 20-24  $\mu\text{m}$  long., 8.5-11  $\mu\text{m}$  lat., maxime polymorphica, ab fusiforme ad cilindricam, circuitus, valde irregularis relatio latus-longus constantis. Collum latum, interdum explanatus, undulatus, obliquum in extremum distale. Polus posterior constrictus gradaliter in caudam circiter amplificatam. Paries hyalinus, tenuis, rugosus. In Tristate Oxbow lacu, Indiana, U.S.A., 6/1/91, 6/13/91, 7/15/91. Iconotypus: figura nostra 73 a.*

Lorica 20-24  $\mu\text{m}$  long, 8.5-11  $\mu\text{m}$  broad, extremely polymorphic, fusiform to cylindrical, lateral margins very irregular, even though the breadth/length relationship is constant (1/2). The pore is surrounded by a wide collar (2.5-4 x 4-5  $\mu\text{m}$ ), somewhat expanded, undulated and oblique in the distal end. The posterior end gradually narrows down to a more or less developed caudus (1.5-5  $\mu\text{m}$ ). Membrane hyaline, thin and rough.

Even though the organism observed were very variable, establishment of a pattern was impossible because of continuous transitions from one morphotype to another shared breadth/length ratio.

*S. napiformis* (Playf.) Defl. var. *brevicollis* Playf. fo. *minor* fo. nov.

Figs. 43 a, b

*A varietate minoribus dimensionibus differt, 31-32  $\mu\text{m}$  long., 17-24.5  $\mu\text{m}$  lat. In Tristate Oxbow lacu, Indiana, U.S.A., 6/13/91. Iconotypus: figura nostra 43 a.*

Lorica 31-32  $\mu\text{m}$  long, 17-24.5  $\mu\text{m}$  broad, collar 4 x 7  $\mu\text{m}$  caudus 5-6  $\mu\text{m}$  long. It differs from the var. *brevicollis* in the smaller dimensions of the envelopes.

*S. oblonga* sp. nov.

Fig. 62

*Lorica 13-14.5  $\mu\text{m}$  long., 11-12.5  $\mu\text{m}$  lat., oblonga, symmetrica. Porus nullis collum, circumventus spissitudine annularis. Polus posterior rotundato. Paries hyalinus, rugosus, leviter undulatus. In Tristate Oxbow lacu, Indiana, U.S.A., 5/4/91, 5/14/91, 6/13/91. Iconotypus: figura nostra 62.*

Lorica 13-14.5  $\mu\text{m}$  long, 11-12.5  $\mu\text{m}$  broad, oblong, symmetrical. Pore without collar, surrounded by an annular thickening. Posterior end rounded. Membrane hyaline, rough, slightly undulated.

This newly established species resembles *Trachelomonas oblonga* Lemm. in lorica shape and dimensions, but it differs mainly in its envelope surface, which is typical of the genus *Strombomonas* (Tell & Conforti, 1984).

*S. pascherana* (Skv.) Defl.

Fig. 59

Lorica 37-40  $\mu\text{m}$  long, 17-21  $\mu\text{m}$  broad, ellipsoidal elongated. Pore wide (5-6  $\mu\text{m}$  diam.). Posterior end slightly asymmetrical and acuminate. Membrane extremely thick (1.5-4  $\mu\text{m}$ ) and coarse, with a very irregular contour.

This species was originally found in China, this is the second place where it is recorded.

*S. recurvata* sp. nov.

Figs. 76 a-g

Lorica 22-29  $\mu\text{m}$  long., 15-18  $\mu\text{m}$  lat., *conspetu rectafronte lata ovoide. Conspetu laterale asymmetrica, dimidium sinistra fusiforme ad cylindricum, latior destera. Conspetu apicale, asymmetrica, piriforme. Collum cylindricum, irregularis et interdum obliquum in extremo distale. Polus posterior rotundato acuminatus. Pariet crassa, ambitus valde irregularis, cum claris densus interiores in base colli; subpallidae ad fuscum. Chromatophora dupliciterque pyrenoidis. In Tristate Oxbow lacu, Indiana, U.S.A., 5/4/91, 5/14/91, 6/1/91, 6/13/91, 7/15/91. Iconotypus: figura nostra 76 a.*

Lorica 22-29  $\mu\text{m}$  long, 15-18  $\mu\text{m}$  broad, 11-14.5  $\mu\text{m}$  thickness, broadly ovate in frontal view. Asymmetrical in lateral view, left half fusiform to cylindrical (fig. 76 f), thicker than the right one (fig. 76 g). Asymmetrical in apical view, pear-shaped. Collar cylindrical (4-5 x 4-5  $\mu\text{m}$ ), irregular and sometimes oblique at the free end. Posterior end rounded to acuminate. Membrane thick, coarse, with very irregular contour and with a clear interior thickening at the collar base, yellowish to light brown. Chromatophores with double-sheathed pyrenoids (fig. 76 d).

In frontal view our specimens resemble *S. scabra* var. *intermedia* (Yacub.) Tell & Conf.; the lateral and apical views of the organism and its considerable smaller dimensions are its main distinguishing features.

*S. scabra* (Playf.) Tell & Conf. var. *cordata* fo. (Defl.) comb. nov.

Fig. 65

*Trachelomonas scabra* var. *cordata* forma?, Deflandre, 1926, Nemours, p. 99, fig. 462

Lorica 14-15  $\mu\text{m}$  long; 13-14  $\mu\text{m}$  broad. This forma was described by Deflandre (1926) in materials from France. This is the only other known record in the world.

var. *coronata* var. nov.

Figs 58 a-d, 95

Lorica 20.5-29  $\mu\text{m}$  long., 17-22  $\mu\text{m}$  lat., *spherica ad late ovoidea, ambitu valde irregulare. Varietas a typo differt per possidere porum circumditus collo forma coronae, configuratus projectionibus irregularibus, divergentes ad extremum distalem. Polus posterior rotundatus leviter acuminatum, cauda conica, breve. In Tristate Oxbow lacu, Indiana, 5/4/91, 5/14/91 et Cypress Cutoff lacu, Alabama, 1/6/91, U.S.A. Iconotypus: figura nostra 58 a.*

Lorica 20.5-29  $\mu\text{m}$  long, 17-22  $\mu\text{m}$  broad, spherical to broadly ovate, with very irregular contour. The distinguishing feature of this variety is the pore surrounded by a crown-shaped collar, which is formed by irregular projections, divergent at the distal end. Hind end rounded to slightly acuminate with a short conical caudus (2-3.5  $\mu\text{m}$  long). Membrane thick, rough, punctated and with numerous adhering particles on its surface, yellowish to reddish-brown.

- var. *ovata* fo. *minor* Tell & Conf. Figs 64 a-c  
 Lorica 15-21  $\mu\text{m}$  long, 9-21  $\mu\text{m}$  long, 9-12.5  $\mu\text{m}$  broad. This forma was recorded only for South America (Argentina, Brazil, Venezuela), this is the first record for North America.
- S. schauinslandii* (Lemm.) Defl. var. *minor* var. nov. Figs. 69 a, b  
*A specie minoribus dimensionibus differt. Lorica 17-18  $\mu\text{m}$  long., 9-10  $\mu\text{m}$  lat.*  
*In* Tristate Oxbow lacu, Indiana, U.S.A. *Iconotypus: figura nostra* 69 a.  
 Lorica 17-18  $\mu\text{m}$  long, 9-10  $\mu\text{m}$  broad. This variety is identical to the typical one, differing only in its smaller dimensions.  
 Tell & Zalocar (1985) found specimens with this new variety dimensions, but they were classified as *S. schauinslandii* var. *schauinslandii*.
- S. urceolata* (Stokes) Defl. var. *minor* var. nov. Figs. 71 a-g  
*A specie minoribus dimensionibus differt. Lorica 26.5-30  $\mu\text{m}$  long., 11-13  $\mu\text{m}$  lat.*  
*In* Tristate Oxbow lacu, Indiana, U.S.A. *Iconotypus: figura nostra* 71 a.  
 Lorica 26.5-30  $\mu\text{m}$  long, 11-13  $\mu\text{m}$  broad. *S. urceolata* var. *minor* differs from the typical variety in the smaller dimensions of the envelopes.
- S. vermontii* (Defl.) Defl. fo. *commune* Popova Figs. 51 a, b  
 Lorica 31.5-43  $\mu\text{m}$  long, 15-28  $\mu\text{m}$  broad, pore 6-6.5  $\mu\text{m}$  diam. This forma was originally found in Russia, ours being the only other known record in the world.

## CONCLUSIONS

Among the 79 taxa of *Trachelomonas* and *Strombomonas* described in this paper, 17 were considered as new taxa; *T. cordata* var. *punctata*, *S. brevicaudata*, *S. conica*, *S. cylindrica*, *S. cylindrica* var. *minor*, *S. elegans*, *S. elongata*, *S. elongata* var. *minor*, *S. globulosa*, *S. lanceolata* var. *minor*, *S. minuta*, *S. napiformis* var. *brevicollis* fo. *minor*, *S. oblonga*, *S. recurvata*, *S. scabra* var. *coronata*, *S. schauinslandii* var. *minor* and *S. urceolata* var. *minor*.

Four were only recorded for America: *T. curta* var. *minima*, *T. cordata* fo. *minor*, *T. rugulosa* var. *parallela*, *S. scabra* var. *ovata* fo. *minor*.

Twenty six were recorded for the first time for U.S.A.; *T. abrupta* var. *minor*, *T. bacillifera* fo. *spasispina*, *T. cordata* fo. *minor*, *T. curta* var. *minima*, *T. granulosa*, *T. hispida* fo. *minor*, *T. lacustris* var. *ovalis*, *T. mangini*, *T. pusilla* var. *punctata*, *T. raciborskii* var. *nova*, *T. selecta*, *T. similis* var. *spinosa*, *T. woycikii* fo. *pusilla*, *S. acuminata* var. *amphora*, *S. asymmetrica*, *S. borysthieniensis*, *S. eurystoma*, *S. eurystoma* fo. *incurva*, *S. lanceolata*, *S. massartii*, *S. rotunda*, *S. scabra* var. *cordata*, *S. scabra* var. *ovata* fo. *minor*, *S. treubii* var. *javanica* and *S. vaseiformis*.

Twenty nine present a widespread distribution.

From the comparison between the four lakes studied, it can be clearly observed that the highest number of taxa was recorded in TOL, where we found 73 taxa, 30 belonging to *Trachelomonas* and 43 to *Strombomonas*. The other three lakes showed

very low numbers: CCL 17 taxa, LKL 8 and TL only 3. From this study we can also verify that in the latter lakes the genus *Strombomonas* presented a low number, only 4 taxa were found in CCL; in TKL and TL this genus was not recorded.

In TOL the samples 4 and 5 were the most diverse presenting 36 and 37 taxa respectively while 1 and 3 showed the lowest number of taxa. These results could indicate the environmental conditions in TOL were more favorable for the development of loricated euglenoids.

#### ACKNOWLEDGEMENTS

We thank Dr. David A. Francko, Dr. Demetrio Boltovskoy and Amelia K. Ward for assistance in this project. We also thank Mrs. Yola Nunley, Laura Sadowsky, and Connie Bricker for their skillful assistance with the scanning electron microscopes. We also wish to extend our gratitude to Prof. Maria Luna for the preparation of the Latin diagnose. This research was partly supported by a grant to D.A. Francko and G.J. Joo from Oxbow Inc.

#### REFERENCES

- BALECH E., 1944 - *Trachelomonas* de la Argentina. *Anales del Mus. Arg. Cs. Nats. B. Rivadavia, Bs. As.* 41: 221-322.
- CONFORTI V. & TELL G., 1986 - Ultraestructura de la lorica de *Trachelomonas* Defl. (Euglenophyta) en microscopio electrónico de barrido (MEB). *Nova Hedwigia* 43 (1-2): 45-79.
- COUTÉ A., THÉRÉZIEN Y., 1985 - Première contribution à l'étude des *Trachelomonas* (Algae, Euglenophyta) de l'Amazonie bolivienne. *Rev. Hydrobiol. Trop.* 18: 111-131.
- DEFLANDRE G., 1926 - *Monographie du genre Trachelomonas Ehr.* Nemours, 162 p.
- DEFLANDRE G., 1930 - *Strombomonas*, nouveau genre d'Euglenacées. *Arch. Protistenk.* 69: 551-614.
- DODGE J.D., 1975 - The fine structure of *Trachelomonas* (Euglenophyceae). *Arch. Protistenk.* 69: 551-614.
- HAGER E., 1979 - *The taxonomic significance of the fine structure of a member of the euglenoid genus Strombomonas.* Ph. D. Dissertation, Fordham University, New York.
- HUBER-PESTALOZZI G., 1955 - Die Binnengewässer. *Das Phytoplankton des Süßwassers* 16 (4), 1135 p. Stuttgart.
- JOO G.-J., 1990 - *Limnological Studies of Oxbow Lakes in the Southeastern United States: Morphometry, Physico-chemical characteristics and patterns of primary productivity.* Ph. D. Dissertation, University of Alabama, Tuscaloosa, 122 p.
- JOO G.-J. & WARD A.K., 1990 a - Morphometric characterization of oxbow lakes along the Black Warrior River, Southern United States. *Verh. Internat. Verein. Limnol.* 24: 524-531.
- JOO G.-J. & WARD A.K., 1990 b - Pattern of phytoplankton productivity in two morphologically different oxbow lakes in the Black Warrior River drainage in Alabama, U.S.A. *In the proceedings of the Vth International Symposium on Lake Environment. Suwa Hydrobiological Station, Shinshu Univ., Nagano, Japan.* pp. 51-60.
- LEEDALE G., 1967 - *Euglenoid Flagellates.* London. Prentice - Hall, Inc., 242 p.
- LEEDALE G., 1975 - Envelope formation and structure in the euglenoid genus *Trachelomonas*. *Br. Phycol. J.* 10: 17-41.

- PHILIPOSE M.T., 1988 - Contribution to our knowledge of Indian algae 3. Euglenineae Part 3. The genera *Trachelomonas* Ehrenberg and *Strombomonas* Deflandre. *Proc. Indian Acad. Sci. (Plant. Sci.)* 98 (5): 317-394.
- POPOVA T.G., 1966 - Euglenophyta. *Trachelomonas, Strombomonas, Eutreptia, Euglena*. *Flora Plant. Cryptog. Moskva* 7: 1-267.
- RINO J.A. & PEREIRA M.J., 1989-90 - Euglenophyta da região centro de Portugal. II. Género *Trachelomonas* Ehr. 1833 emend. Defl. 1926. II. Estrutura da lorica em microscopia electrónica de varrimento. *Rev. Biol. Univ. Aveiro* 3: 139-187.
- SKVORTZOV B.W., 1922 - Notes on the agriculture, botany and zoology of China. *Jour. of the North China Branch of the Roy. Asiat. Soc.* 53.
- STARMACH K., 1983 - *Flora sladkowodna Polski*, 3. Von Christian Steinberg, Wolfgang Müller und Rolfklee Bayerisches Landesamt f. wassrwirtschaft München, BDR und Wasser wirtschaftsamt, Regensburg, 594 p.
- TELL G. & CONFORTI V., 1984 - Ultraestructura de la lóriga de cuatro especies de *Strombomonas* Defl. (Euglenophyta) en M.E.B. *Nova Hedwigia* 40: 123-131.
- TELL G. & CONFORTI V., 1986 - *Euglenophyta pigmentadas de la Argentina*. *Bibliotheca Phycologica* 75, 301 p. J. Cramer, Berlin-Stuttgart.
- TELL G. & CONFORTI V., 1988 - Quelques *Strombomonas* Defl. (Euglenophyta) de l'Argentine au microscope photonique et électronique à balayage. *Nova Hedw.* 45: 541-556.
- TELL G. & ZALOCAR Y., 1985 - *Euglenophyta pigmentadas de la provincia del Chaco (Argentina)*. *Nova Hedwigia* 41: 353-391.

## LEGENDS

Fig. 1. *T. volvocina*; 2. *T. volvocina* var. *punctata*; 3. *T. curta* var. *minima*; 4. *T. pusilla*; 5. *T. pusilla* var. *punctata*; 6. *T. oblonga*; 7. *T. oblonga* var. *attenuata*; 8. *T. oblonga* var. *truncata*; 9. *T. intermedia*; 10. *T. dybowskii*; 11. *T. zorensis*; 12. *T. nexilis*; 13. *T. rugulosa*; 14. *T. rugulosa* fo. *parallela*; 15. *T. minima*; 16. *T. sselecta*; 17. *T. woycikii* fo. *pusilla*; 18. *T. hispida* fo. *minor*; 19. *T. hispida*; 20. *T. abrupta* var. *minor*; 21. *T. verrucosa* fo. *irregularis*; 22. *T. robusta*; 23. *T. similis* var. *spinosa*; 24. *T. granulosa*; 25. *T. bacillifera* var. *minima*; 26. *T. bacillifera* fo. *sparsispina*; 27. *T. mangini*; 28. *T. silvatica*; 29. *T. crebea*; 30. *T. cordata*; 31. *T. cordata* var. *punctata*; 32. *T. granulata*; 33. *S. eurystoma*; 34. *S. eurystoma* fo. *synensis*; 35 a, b. *S. eurystoma* fo. *incurva*; 36 a-c. *S. acuminata*; 37. *S. massartii*; 38 a-c. *S. acuminata* var. *amphora*; 39 a, b. *S. verrucosa* var. *zniewika*; 40. *S. borysthienensis*; 41. *S. gibberosa*; 42. *S. praeliaris*; 43 a, b. *S. urceolata*; 45. *S. treubii* var. *javanica*; 46. *S. verrucosa* var. *genuina*; 47 a, b. *S. rotunda*.

Fig. 48 a, b. *S. fluviatilis*; 49 a-c. *S. lanceolata*; 50. *S. asymmetrica*; 51 a, b. *S. vermontii* fo. *commune*; 52 a, b. *S. aspera*; 53 a-c. *S. schauinslandii*; 54. *S. scabra*; 55. *S. scabra* var. *cordata*; 56 a, b. *S. scabra* var. *coberensis*; 57. *S. scabra* var. *longicollis*; 58 a-d. *S. scabra* var. *coronata*; 59. *S. pascherana*; 60 a, b. *S. cylindrica* var. *minor*; 61 a-c. *S. conica*; 62. *S. oblonga*; 63 a-g. *S. cylindrica* var. *cylindrica*, a. apical view, b-g. general views; 64 a-c. *S. scabra* var. *ovata* fo. *minor*; 65. *S. scabra* var. *cordata* fo.; 66 a, b. *S. globulosa*; 67 a, b. *S. brevicaudata*; 68 a-b. *S. elongata* var. *minor*; 69 a, b. *S. schauinslandii* var. *minor*; 70 a, b. *S. lanceolata* var. *minor*; 71 a-g. *S. urceolata* var. *minor*; 72 a, b. *S. elongata*.

Fig 73 a-m. *S. minuta*; 74 a-d. *S. elegans*; 75 a, b. *S. vaseformis*; 76 a-g. *S. recurvata*, a-c. general views, e. apical views, d-f-g. lateral views.

Figs. 77, 78. *T. volvocina* var. *volvocina*; 79. *T. volvocina* var. *volvocina* and *T. verrucosa* fo. *irregularis*; 80. *T. verrucosa* fo. *irregularis*; 81, 82. *T. cordata* fo. *minor*, general view and detail of the anterior end showing the collar; 83 *T. intermedia*; 84. *T. raciborskii* var. *nova*; 85. *T. racyborskii* var. *racyborskii*.

Fig. 86. *T. robusta*; 87. *T. bacillifera* var. *minima*; 88. *T. lacustris* var. *ovalis*; 89-91. *T. abrupta* var. *minor*; 89. general view; 90-91. Detail of envelope ornamentation; 92. *S. cylindrica* var. *cylindrica*; 93-94. *T. cylindrica* var. *minor*; 93. general view; 94. anterior end showing detail of the pore and envelope surface; 95. *S. scabra* var. *coronata*.











